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IS 1068 (1993): Electroplated coatings of nickel plus chromium and copper plus nickel plus chromium [MTD 7: Light Metals and their Alloys]



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भारतीय मानक

क्रोमियम एवम् निकेल तथा तांबे निकेल एवम्
क्रोमियम के विद्युत निक्षेपित लेपन — विशिष्ट

(तीसरा पुनरीक्षण)

Indian Standard

ELECTROPLATED COATINGS OF NICKEL
PLUS CHROMIUM AND COPPER PLUS
NICKEL PLUS CHROMIUM — SPECIFICATION

(Third Revision)

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FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Metallic and Non-Metallic Finishes Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1958 and subsequently revised in 1968 and 1985, respectively. Electrodeposited coatings of Ni plus Cr and Cu + Ni + Cr that are applied to zinc alloys, copper and copper alloys, and aluminium and aluminium alloys which are presently covered in IS 4827, IS 4828 and IS 4942 respectively, have now been incorporated in this revision to have unification of the requirements of these coatings on line with International Standards.

After the publication of this standard, IS 4827 : 1983 'Electroplated coatings of nickel and chromium on copper and copper alloys (*first revision*)', IS 4828 : 1983 'Electroplated coatings of copper, nickel and chromium on zinc alloys (*first revision*)' and IS 4942 : 1983 'Electroplating coating of nickel and chromium on aluminium and aluminium alloys (*first revision*)' shall be withdrawn.

In the preparation of this standard considerable assistance has been derived from ISO 1456 : 1988 Metallic coatings — Electroplated coatings of nickel plus chromium and of copper plus nickel plus chromium.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTROPLATED COATINGS OF NICKEL PLUS CHROMIUM AND COPPER PLUS NICKEL PLUS CHROMIUM — SPECIFICATION

(*Third Revision*)

1 SCOPE

1.1 This standard covers requirements for nickel plus chromium and for copper plus nickel plus chromium electrodeposited coatings that are applied to iron, steel, zinc alloys, copper and copper alloys, and aluminium and aluminium alloys to provide an attractive appearance and corrosion resistance. Several classes of coatings are provided that differ in thickness and type and guidance is given in selecting the coating class appropriate to the service conditions to which the coated product will be exposed.

1.2 This standard does not specify the surface condition required by the basis metal prior to the coating process.

1.3 This standard is not applicable to coatings on sheet, strip or wire in the unfabricated form nor to threaded fasteners or coil springs.

2 REFERENCES

2.1 The standards given below are necessary adjuncts to this standard:

<i>IS No.</i>	<i>Title</i>
3203 : 1982	Methods of testing local thickness of electroplated coatings (<i>first revision</i>)
5528 : 1985	Method of testing corrosion resistance of electroplated and anodized aluminium coating by copper accelerated acetic acid salt spray (CASS) test (<i>first revision</i>)
6009 : 1970	Method for evaluation of results of accelerated corrosion tests
6910 : 1985	Method of testing corrosion resistance of electroplated and anodized aluminium coatings by acetic acid salt spray test (<i>first revision</i>)
8038 : 1985	Method of testing corrosion resistance of metallic and non-organic coatings by corrodokote test (<i>first revision</i>)

3 SIGNIFICANT SURFACE

3.1 For the purpose of this standard, a significant surface is defined as the part of surface of an article which being essential to the appearance or serviceability of that article is required to be coated by a specified thickness of copper, nickel and chromium, in the stipulated combinations as specified in Tables 1A to 4.

3.1.1 When necessary, the significant surface should be the subject of agreement, and should be indicated on drawings, or by the provision of suitably marked samples.

4 INFORMATION TO BE SUPPLIED BY THE PURCHASER TO THE ELECTROPLATER

4.1 Essential Information

When ordering articles to be electroplated in accordance with this standard, the purchaser shall provide the following information.

4.1.1 The number of this standard.

4.1.2 The basis metal and either the service condition number (*see 5.1*) denoting the severity of the conditions to be withstood by the coated article or the classification code (*see 5.2*) of the particular coating required.

If the basis metal and the service condition number are quoted and not the classification code, the electroplater is free to supply any of the classes of coating corresponding to the service condition number, but he shall inform the purchaser of the classification code of the coating which he has selected (*see also 7.2*).

4.1.3 The finish required, for example, bright, dull, or satin (*see 7.2*). Alternatively samples showing the required finish or range of finish shall be supplied or approved by the purchaser.

4.1.4 Significant surfaces, to be indicated on drawings of the parts, or by the provision of suitably marked specimens.

4.1.5 The type of corrosion test to be used.

4.1.6 The type of adhesion test to be used.

4.1.7 The extent to which defects shall be tolerated on non-significant surfaces.

4.1.8 The positions on the significant surface for rack or contact marks, where such marks are unavoidable.

4.1.9 Sampling methods and acceptance levels.

4.2 Additional Information

The following additional information may be provided by the purchaser, when appropriate.

4.2.1 The tensile strength of the steel and any requirement for heat treatment either before or after electroplating.

4.2.2 Thickness requirements on those areas, that cannot be touched by a ball 20 mm in diameter.

4.2.3 Whether or not a copper undercoat is required.

5 CLASSIFICATION

5.1 Service Condition Number

The service condition number is used by the purchaser to specify the degree of protection required, as related to the severity of the conditions to which a product is to be subjected, in accordance with the following scale:

- 4 = Extremely severe
- 3 = Severe
- 2 = Moderate
- 1 = Mild
- 0 = Exceptionally mild

Typical service conditions for which the various service condition numbers are appropriate are listed in Annex A.

5.2 Coating Classification Code

The coating classification code comprise the following:

- a) The chemical symbol for the basis metal (or for the principal metal if an alloy) followed by a stroke, as follows:
 - Fe / for iron or steel
 - Zn / for zinc alloys
 - Cu / for copper or copper alloys
 - Al / for aluminium or aluminium alloys
- b) The chemical symbol for copper (Cu), if copper or brass containing greater than 50 percent copper, is used as an undercoat

- c) A number indicating the minimum local thickness, in micrometres, of the copper coating where applicable.
- d) The chemical symbol for nickel (Ni).
- e) A number indicating the minimum local thickness, in micrometres, of the nickel coating.
- f) A letter designating the type of nickel coating (see 7.2.3.2).
- g) The chemical symbol for chromium (Cr).
- h) A letter or letters designating the type of chromium coating and its minimum thickness.

Example of complete classification code : A coating on steel comprising 20 µm copper (minimum) plus 30 m bright nickel (minimum) plus 0.3 µm micro-cracked chromium (minimum) has the classification code.

Fe/Cu20 Ni30b Cr mc

NOTE — For nickel plus chromium and copper plus nickel plus chromium coatings, the minimum thickness requirements apply only to those portions of the significant surface that can be touched by a ball 20 mm in diameter unless otherwise specified by the purchaser.

5.3 Coating Appropriate to Each Service Condition Number

Tables 1A to 4 show, for various basis metals, the coating classification codes appropriate for each service condition number.

6 HEAT TREATMENT OF STEEL

6.1 If the purchaser specifies that heat treatment is necessary before and/or after electroplating, it shall be carried out in accordance with the appropriate recommendations given in Annex B.

7 COATING REQUIREMENTS

7.1 Appearance

Over the significant surface, there shall be no clearly visible plating defects such as blisters, pits, roughness, cracks, unplated areas, stains or discoloration. The extent to which defects may occur on non-significant surfaces shall be specified by the purchaser. Where rack marks on the significant surface are unavoidable, their position shall be specified by the purchaser.

7.2 Thickness and Type of Coatings

7.2.1 General

For a specified service condition number, the thickness and type of coating shall correspond to the classification codes given in Tables 1A to 4. The minimum allowable thickness for the metal coatings shall be required on any point of the significant surface that can be touched by a ball 20 mm in diameter and the purchaser may also specify that other points shall meet those thickness requirements.

Test methods for determining coating thickness are specified in 9.1.

Table 1A Nickel Plus Chromium Coatings on Iron or Steel
(Clauses 3.1, 5.3, 7.2.1 and 7.2.4.1)

Service Condition Number	Classification Code
4	Fe/Ni 40d Cr r Fe/Ni 30d Cr mc Fe/Ni 30d Cr mp Fe/Ni 40p Cr r Fe/Ni 30p Cr mc Fe/Ni 30p Cr mp
	Fe/Ni 30d Cr r Fe/Ni 25d Cr mc Fe/Ni 25d Cr mp Fe/Ni 30p Cr r Fe/Ni 25p Cr mc Fe/Ni 25p Cr mp Fe/Ni 40b Cr r Fe/Ni 30b Cr mc Fe/Ni 30b Cr mp
2	Fe/Ni 20b Cr r
1	Fe/Ni 10b Cr r
0	Fe/Ni 05b Cr r

NOTE — s Nickel may be substituted for b nickel, and mc or mp chromium may be substituted for r chromium for service conditions 3, 2, 1 and 0. p and d nickel may be substituted for b nickel for service conditions 2 and 1.

Table 1B Copper Plus Nickel Plus Chromium Coatings on Iron or Steel
(Clauses 3.1, 5.3, 7.2.1, 7.2.2 and 7.2.4.1)

Service Condition Number	Classification Code
4	Fe/Cu 20 Ni 30d Cr r Fe/Cu 20 Ni 25d Cr mc Fe/Cu 20 Ni 25d Cr mp Fe/Cu 20 Ni 30p Cr r Fe/Cu 20 Ni 25p Cr mc Fe/Cu 20 Ni 25p Cr mp Fe/Cu 20 Ni 30b Cr mc Fe/Cu 20 Ni 30b Cr mp
3	Fe/Cu 15 Ni 25d Cr r Fe/Cu 15 Ni 20d Cr mc Fe/Cu 15 Ni 20d Cr mp Fe/Cu 15 Ni 25p Cr r Fe/Cu 15 Ni 20p Cr mc Fe/Cu 15 Ni 20p Cr mp Fe/Cu 20 Ni 35b Cr r Fe/Cu 20 Ni 25b Cr mc Fe/Cu 20 Ni 25b Cr mp
2	Fe/Cu 20 Ni 10b Cr r
1	Fe/Cu 10 Ni 05b Cr r
0	Fe/Cu 05 Ni 05b Cr r

NOTE — s Nickel may be substituted for b nickel, and mc or mp chromium may be substituted for r chromium for service conditions 3, 2, 1 and 0. p and d nickel may be substituted for b nickel for service condition 2.

Table 2A Nickel Plus Chromium Coatings on Zinc Alloys
(Clauses 3.1, 5.3, 7.2.1, 7.2.2 and 7.2.4.1)

Service Condition Number	Classification Code
	Zn/Cu Ni 35d Cr r Zn/Cu Ni 25d Cr mc Zn/Cu Ni 25d Cr mp
4	Zn/Cu Ni 35p Cr r Zn/Cu Ni 25p Cr mc Zn/Cu Ni 25p Cr mp
	Zn/Cu Ni 35b Cr mc Zn/Cu Ni 35b Cr mp
3	Zn/Cu Ni 25d Cr r Zn/Cu Ni 20d Cr mc Zn/Cu Ni 20d Cr mp Zn/Cu Ni 25p Cr r Zn/Cu Ni 20p Cr mc Zn/Cu Ni 20p Cr mp
	Zn/Cu Ni 35b Cr r Zn/Cu Ni 25b Cr mc Zn/Cu Ni 25b Cr mp
2	Zn/Cu Ni 15b Cr r
0 and 1	Zn/Cu Ni 08b Cr r

NOTES

1 s nickel may be substituted for b nickel, and mc or mp chromium may be substituted for r chromium for service conditions 3, 2 and 1. p and d nickel may be substituted for b nickel for service condition 2.

2 Thinner coatings than those given for service condition 1 are not specified for service condition 0.

3 A copper undercoat of at least 8 µm shall be given in all the cases.

7.2.2 Thickness of Copper Coating

For copper plus nickel plus chromium coatings, the minimum thickness for copper is indicated in the classification codes given in Tables 1B and 2B. The minimum copper thickness for a system of nickel plus chromium on zinc alloys is 8 µm (see Table 2A).

NOTE — All the nickel coatings given in Table 2A are applied over an undercoat of copper having a thickness of at least 8 µm [see 5.2(b) and 7.2.2]. However, for articles of complex shape, the minimum thickness of copper on the significant surface may need to be increased to 10 µm or 12 µm in order to achieve adequate coverage on low-current areas outside the significant surfaces.

7.2.3 Thickness and Type of Nickel Coatings

7.2.3.1 Thickness of nickel coating

The total minimum thickness of nickel shall be that designated by the classification code (see 5.2).

Table 2B Copper Plus Nickel Plus Chromium Coatings on Zinc Alloys [see also 5.2(b)]
(Clauses 3.1, 5.3, 7.2.1, 7.2.2 and 7.2.4.1)

Service Condition Number	Classification Code
3	Zn/Cu 20 Ni 30d Cr r
	Zn/Cu 20 Ni 20d Cr mc
	Zn/Cu 20 Ni 20d Cr mp
	Zn/Cu 20 Ni 30p Cr r
	Zn/Cu 20 Ni 20p Cr mc
	Zn/Cu 20 Ni 20p Cr mp
	Zn/Cu 20 Ni 30d Cr mc
	Zn/Cu 20 Ni 30d Cr mp
	Zn/Cu 15 Ni 20d Cr r
	Zn/Cu 15 Ni 15d Cr mc
	Zn/Cu 15 Ni 15d Cr mp
	Zn/Cu 20 Ni 30b Cr r
	Zn/Cu 20 Ni 20b Cr mc
	Zn/Cu 20 Ni 20b Cr mp
	Zn/Cu 15 Ni 20p Cr r
	Zn/Cu 15 Ni 15p Cr mc
	Zn/Cu 15 Ni 15p Cr mp
2	Zn/Cu 20 Ni 10b Cr r
0 and 1	This coating systems given in Table 2A for service condition number 1 shall apply here.

NOTE — s nickel may be substituted for b nickel, and mc or mp chromium may be substituted for r chromium for service conditions 3, 2 and 1; p and d nickel may be substituted for b nickel for service condition 2.

Table 3 Nickel Plus Chromium Coatings on Copper or Copper Alloys
(Clauses 3.1, 5.3, 7.2.1 and 7.2.4.1)

Service Condition Number	Classification Code
4	Cu/Ni 30d Cr r
	Cu/Ni 25d Cr mc
	Cu/Ni 25d Cr mp
	Cu/Ni 30p Cr r
	Cu/Ni 25p Cr mc
	Cu/Ni 25p Cr mp
3	Cu/Ni 30b Cr mc
	Cu/Ni 30b Cr mp
3	Cu/Ni 25b Cr r
2	Cu/Ni 10b Cr r
1	Cu/Ni 05b Cr r
0	Cu/Ni 03b Cr r

NOTE — s nickel may be substituted for b nickel, and mc or mp chromium may be substituted for r chromium for service conditions 3, 2, 1 and 0. p and d nickel may be substituted for b nickel for service conditions 3 and 2.

Table 4 Coatings of Nickel Plus Chromium on Aluminium or Aluminium Alloys
(Clauses 3.1, 5.3, 7.2.1 and 7.2.4.1)

Service Condition Number	Classification Code
4	Al/Ni 50d Cr r
	Al/Ni 35d Cr mc
	Al/Ni 35d Cr mp
	Al/Ni 30d Cr r
	Al/Ni 25d Cr mc
	Al/Ni 25d Cr mp
3	Al/Ni 35p Cr r
	Al/Ni 30p Cr mc
	Al/Ni 30p Cr mp
2	Al/Ni 20b Cr r
0 and 1	Al/Ni 10b Cr r

NOTES

1 A copper undercoat in addition to the specified nickel coatings may be used on certain alloys and the certain applications.

2 p, d or s nickel may be substituted for b nickel, and mc or mp chromium may be substituted for r chromium for service conditions numbers 2 and 1.

7.2.3.2 Type of nickel coating

The type of nickel coating shall be designated by the following symbols:

'b' for nickel deposited in the fully bright condition;

'p' for dull or semi-bright nickel which has been mechanically polished;

's' for dull satin, or semi-bright nickel which shall not have been mechanically polished; and

'd' for double or triple-layer coatings; the requirements for such coatings are given in Table 5.

NOTES

1 The test method for the determination of specific elongation is specified in Annex C.

2 The sulphur contents are specified in order to indicate the type of nickel plating solution that is to be used. No simple method exists for determining the sulphur content of a nickel deposit on a coated article. However, an accurate determination is possible on a specially prepared test specimen using either of the methods specified in Annex D.

3 It will usually be possible to identify the type and to determine the ratios of thicknesses of nickel layers by microscopical examination of a polished and etched section of an article prepared in accordance with IS 3203 : 1982.

7.2.4 Thickness and Type of Chromium Coating

7.2.4.1 Thickness of chromium coating

The thickness of the chromium coatings shall be as follows:

— Regular (conventional) chromium (designated Cr r) — minimum thickness 0.3 μ m

- Micro-cracked chromium (designated Cr mc) — minimum thickness of 0.3 μm (see Notes 1 and 2)
- Micro-cracked chromium (designated Cr mc 0.5) — minimum thickness 0.5 μm (see Note 2 and Note under 7.2.4.2)
- Micro-cracked chromium (designated Cr mp) — minimum thickness 0.3 μm (see Note 2)
- Micro-porous chromium (designated Cr mp 0.5) — minimum thickness 0.5 μm (see Note 2)

NOTES

1 With some processes a substantially greater thickness, approximately 0.8 μm , may be required to achieve the necessary crack pattern.

2 There may be some loss of lustre after a period of service in the case of mp or mc chromium deposits which may be unacceptable in some applications. This tendency may be reduced by increasing the minimum chromium coating thickness to 0.5 μm in every case where micro-porous or micro-cracked chromium is specified in Tables 1A to 4.

7.2.4.2 Type of chromium coating

The type of chromium coating is designated by placing symbols after the chemical symbol, Cr as follows:

Cr r for regular chromium;

Cr mc for micro-cracked chromium which, when tested by the method described in Annex E, has more than 250 cracks per centimetre in any direction and form a closed network over the whole significant surface;

Cr mp for micro-porous chromium which, when tested by the method specified in Annex E, contains at least 10 000 pores per square centimetre (see Note).

NOTE — This type of coating is often achieved by depositing chromium over a special thin nickel layer which contains inert non-conducting particles, the special nickel layer being applied on top of b, s, p or d nickel.

7.3 Adhesion

The coating shall be sufficiently adherent to the basis metal, and the separate layers of a multilayer coating shall be sufficiently adherent to each other, to pass the appropriate test specified in 9.2.

7.4 Corrosion Resistance

Coated articles shall be sufficiently corrosion-resistant and pore-free to pass the appropriate test specified in 9.3 for the particular service condition number. The performance rating shall be determined in accordance with IS 6009. The minimum acceptance rating, after testing in accordance with 9.3 shall be a rating of 9.

NOTE — For a quick identification for performance of pore free Ni, modified ferroxyl test may be used, as given in Annex F.

8 SELECTION OF SAMPLES

8.1 Out of each lot of similar parts, a number of samples shall be selected at random. The size of the lot and the number of samples to be selected shall be agreed upon between the manufacturer and the purchaser. All of the samples selected shall be visually examined for any defects referred to in 7.1.

9 METHODS OF TEST

9.1 Thickness

9.1.1 The thickness of a coating and its various layers shall be measured at any part of the significant surface that can be touched by a ball 20 mm diameter. The coulometric method described in Annex G may be used to measure the thickness of the chromium, the total thickness of the nickel, the thickness of the copper and the thickness of a copper alloy undercoat, if its composition is known. In case the instrument specified in Annex G is not available, the method given in IS 3203 : 1982 may be used.

9.1.2 The microscopical method specified in IS 3203 : 1982 may be used to measure the thickness of each nickel layer where the minimum thickness is 10 μm , and of a copper or copper alloy undercoat, when present (see 7.2).

Table 5 Requirements for Double or Triple Layer Nickel Coatings

(Clause 7.2.3.2)

Layer (Type of Nickel Coating)	Specific Elongation Percent (see Note 1)	Sulphur Content Percent (m/m) (see Note 2)	Thickness, as a Percentage of Total Nickel Thickness (see Note 3)	
			Double Layer	Triple Layer
Bottom(s)	> 8	< 0.005	≥ 60	≥ 50
Middle				
High-sulphur (b)	—	> 0.15	—	10
Top (b)	—	> 0.04 and 0.15	≤ 40	≤ 40

9.1.3 The magnetic method specified in IS 3203 : 1982 may be used to measure the total thickness of b, d, s or p nickel on zinc alloys and copper alloys and on ferrous materials, if an appropriate calibration is made.

NOTE — Other methods may also be used if it can be demonstrated that the uncertainty of the measurement is less than 10 percent.

9.1.4 In case of dispute, coulometric method shall be used for measuring the thickness of the chromium coating and for nickel coatings of the thickness less than 10 µm and the microscope method shall be used for measuring the thickness of nickel coatings and the undercoat of thickness 10 µm and above.

9.2 Adhesion

Adhesion of the coating shall be tested by either the file test or the quenching methods specified in Annexes H and J. There shall not be any detachment of the coating from the substrate, or any separation between layers of the coating.

9.3 Corrosion Resistance

9.3.1 Coated articles shall be subjected to one of the corrosion tests given in Table 6, appropriate for the particular service grade number.

9.3.2 After the articles have been subjected to the appropriate corrosion test the rating shall be assigned, using the method described in IS 6009 : 1970, to each tested article representing the relative freedom from defects at which the coating is penetrated, with

resulting the corrosion of the basis metal (see 7.4). The rating shall be at least 9.

9.3.3 Corrosion Test

Corrosion tests, when carried out in accordance with the test prescribed in 7.4 are meant for controlling continuity of the coating and the duration of the tests does not necessarily have a fixed relationship with the service life of the finished article.

NOTES

1 The duration of tests is less when the basis metal is copper or copper alloy than when it is iron or steel, zinc alloy or aluminium alloy. This is necessary since, for the same service condition number, the nickel deposits on copper and copper alloy are thinner than those on iron or steel, zinc alloy or aluminium alloy. The use of these thinner and less corrosion-resistant coatings is justified by the slower corrosion of copper and copper alloys when the coating are penetrated.

2 Dashes indicate that there is no test requirement.

3 No corrosion test is specified for service condition 0.

9.4 Ductility

The ductility shall be such that the elongation will be not less than specified in 7.2.3.2 for nickel when tested in accordance with the method specified in Annex C.

10 MARKING

10.1 The material may also be marked with the Standard Mark.

Table 6 Corrosion Tests Appropriate for Each Service Condition Number

(Clause 9.3.1)

Basis Metal	Service Condition	CASS Test (IS 5528 : 1985)	Duration of Corrosion Test, h	
			Corrodokote Test (IS 8038 : 1985)	Acetic Acid Salt Spray Test (IS 6910 : 1985)
Steel	4	24	2 × 16	144
	3	16	16	96
	2	8	8	48
	1	—	—	8
Zinc alloy	4	24	2 × 16	144
	3	16	16	96
	2	8	8	48
	1	—	—	8
Copper or copper alloy	4	16	—	96
	3	—	—	24
	2	—	—	8
	1	—	—	—
Aluminium or aluminium alloy	4	24	2 × 16	144
	3	16	16	96
	2	8	8	48
	1	—	—	8

ANNEX A

(Clause 5.1)

EXAMPLES OF SERVICE CONDITIONS FOR WHICH THE VARIOUS SERVICE
CONDITION NUMBERS ARE APPROPRIATE

A-1 Examples of service conditions for which the various service condition numbers are appropriate are as follows:

Service condition 4. Service outdoors in extremely severe corrosive conditions

Service condition 3. Service outdoors in severe temperate conditions

Service condition 2. Service indoors in places where condensation may occur

Service condition 1. Service indoors in warm dry atmospheres

Service condition 0. Purely cosmetic applications

ANNEX B

(Clause 6.1)

RECOMMENDATIONS FOR HEAT TREATMENT OF STEEL

B-1 Heat treatment is normally necessary for some steels to reduce the risk of damage by hydrogen embrittlement and can comprise:

a) stress relief before electroplating; and

b) heat treatment after electroplating.

Recommendations for such treatment are summarized in Table 7.

Table 7 Recommendations for Heat Treatment of Steels

(Clause 6, and Annex B)

Before Electroplating		After Electroplating		
Steel Components Normally Requiring Heat Treatment	Components that have been severely cold worked or that are made from steel of tensile strength of 1 000 MPa (or corresponding hardness*) or greater, that have been ground or subjected to severe machining after tempering	Components that are made from severely cold-worked steels or from steels of tensile strength of 1 000 MPa (or corresponding hardness*) and that are subject to fatigue or sustained loading stress in service.		
Heat treatment:				
a) General recommendations	30 min at the highest temperature within the limit imposed by the tempering temperature but not higher than 50°C below the tempering temperature or 1 h minimum at a temperature of between 190° and 210°C	Tensile Strength MPa	Maximum Thickness of Component mm	Minimum Period at 190° to 210°C h
		> 1 000 and < 1 50	Less than 12 12 to 25 Over 25	2 4 8
		> 1 150 and < 1 400	Less than 12 12 to 25 Over 25	4 12 24
				Heating to commence within 16 hours of plating
b) Restrictions	Steels that have been carburized, flame - or induction-hardened shall be heated at a lower temperature for a longer period, for example more than 1 h at a temperature of 170°C	If the components have been surface-hardened, they shall be heated at a lower temperature for a longer period, provided that these conditions have been shown to be effective for a particular component and are acceptable to the purchaser		

*30 HRC, 295 HV, 280 HB (approximate values).

ANNEX C

(*Clauses 7.2.3.2 and 9.4*)

DUCTILITY TEST

C-1 SCOPE AND FIELD OF APPLICATION

This annex specifies a method for determining the specific elongation of the coating on an electrocoated test piece and provides a means of assessing the ductility of the coating.

C-2 PRINCIPLE

Bending a nickel coated test piece around a mandrel in order to produce a minimum elongation in the coating of 8 percent and visual examination to observe whether or not cracking has taken place in the coating.

C-3 APPARATUS

Mandrel, diameter 11.5 ± 1.0 mm.

C-4 PROCEDURE

C-4.1 Preparation of Test Piece

Prepare a coated test piece 150 mm long, 10 mm wide and 1.0 ± 0.1 mm thick as follows.

Polish a sheet of the appropriate basis metal, similar to that of the articles being coated, except that the sheet may be of soft brass if the basis metal is zinc alloy. Use a sheet that is sufficiently large to allow

the test strip to be cut from it after trimming off a border at least 25 mm wide all round.

Electroplate the polished side of the sheet with nickel to a thickness of 25 mm under the same conditions and in the same bath as used with the corresponding articles.

Cut the test piece from the coated sheet with a guillotine or flat shear. Round or chamfer the longer edges of the test strip, at least on the plated side, by careful filing or grinding.

C-4.2 Test

Bend the test piece (C-4.1) with the coated side in tension, by steadily applied pressure, through 180° over the mandrel (C-3) until the two ends of the test piece are parallel. Ensure that contact between the test piece and the mandrel is maintained during bending. Examine the convex side of the bent test piece visually for cracks.

C-5 EXPRESSION OF RESULTS

If there are no cracks in the nickel coating on the test piece which have propagated completely over the convex surface (*see Note*), the coating is deemed to have a specific elongation of 8 percent or greater and is deemed to have passed the test.

NOTE — Short cracks in the nickel coating at the edges of the test piece do not indicate failure.

ANNEX D

(*Clause 7.2.3.2*)

DETERMINATION OF SULPHUR CONTENT OF ELECTRODEPOSITED NICKEL

D-0 GENERAL

Two methods are given for the determination of sulphur, to be used for testing compliance of the type of nickel deposit with the appropriate requirements of 7.2.3.2. For routine purpose, alternative methods or variations of these methods may be used, by agreement between the purchaser and the supplier.

D-1 DETERMINATION BY COMBUSTION AND IODATE TITRIMETRY

D-1.1 Scope and Field of Application

This part of this annex specifies a combustion/

titrimetric method for the determination of the sulphur content of electrodeposited nickel. It is applicable to products having sulphur contents, expressed as S, in the range 0.005 to 0.5 percent (m/m).

D-1.2 Principle

Combustion of a test portion in stream of oxygen in an induction furnace. Absorption of sulphur dioxide evolved in acidified potassium iodide/starch solution. Titration with potassium iodate solution which has been freshly standardized against steel of known sulphur content to compensate for the characteristics of the apparatus and for day-to-day variation in sulphur dioxide recovery. Compensation is made for

the blank to allow for the effects of crucibles and accelerators.

D-1.3 Interferences

The elements normally present in electrodeposited nickel do not interfere.

D-1.4 Reagents

During the analysis, use only reagents of recognized analytical grade and only distilled water or water of equivalent purity.

D-1.4.1 Dilute Hydrochloric Acid, 3 percent (v/v).

D-1.4.2 Iron (Low-Sulphur) Accelerator, in chip form.

D-1.4.3 Iron (Low-Sulphur) Accelerator, in powder form.

D-1.4.4 Potassium Iodate, standard solution A, equivalent to 0.10 g of S per litre.

Dissolve 0.222 5 g of potassium iodate (KIO_3) in 900 ml of water in a volumetric flask.

1 ml of this standard solution is equivalent to 0.10 mg of S.

D-1.4.5 Potassium Iodate, standard solution B, equivalent to 0.02 g of S per litre.

Transfer 200 ml of the potassium iodate solution A (D-1.4.4) to a 1 000 ml one mark volumetric flask, dilute to the mark and mix.

1 ml of this standard solution is equivalent to 0.02 mg of S.

NOTE — The sulphur equivalent assumes complete conversion of sulphur to sulphur dioxide. However, the recovery of sulphur as sulphur dioxide may be less than 100 percent. It is nevertheless consistent if the temperature and the rate of oxygen flow in the furnace remain constant. It is therefore necessary to determine an analysis factor by analysis of a standard sample.

D-1.4.6 Starch, iodide solution.

Transfer 1 g of soluble starch to small beaker, add 2 ml of water and stir until a smooth paste is obtained. Pour the water into 50 ml of boiling water. Cool, add 1.5 g of potassium iodide (KI) and stir until it is dissolved. Dilute to 100 ml and stir.

D-1.4.7 Tin (Low Sulphur) Accelerator, Granular

D-1.4.8 Oxygen, pure.

D-1.5 Standards

Certified standard steel, of appropriate sulphur content, shall be used.

D-1.6 Apparatus

- a) Ordinary laboratory apparatus;

- b) Induction heating apparatus, comprising essentially:

- i) oxygen purifying tubes, to remove any residual impurities from the oxygen (D-1.4.8) leading to
- ii) valve, for controlling oxygen flow rate through the heating tube, leading to
- iii) heating tube, located in the induction furnace, leading to
- iv) sulphur dioxide absorption vessel, filled with a burette,
- v) induction furnace.

WARNING — TAKE APPROPRIATE PRECAUTIONS IN USING THE INDUCTION FURNACE.

- c) Crucible, fitted with lid, to contain the test portion.

D-1.7 Procedure

D-1.7.1 Nickel Test Foil Preparation

D-1.7.1.1 Prepare a suitably dimensioned test panel of cold-rolled steel, for example, 150 mm long \times 100 mm wide \times 1 mm thick. Clean and acid-dip the panel, electroplate it with approximately 7.5 mm of an adherent nickel deposit and thoroughly rinse. Buffed nickel or buffed stainless steel may also be used as alternatives to steel electroplated with nickel.

D-1.7.1.2 Passivate the test panel anodically at 3V for 5 to 10 s in an alkaline cleaner solution maintained at 70° to 80°C and containing either 30 g/l of sodium hydroxide (NaOH) and 30 g/l of trisodium orthophosphate (Na_3PO_4), or 60 g/l of any other suitable anodic alkaline cleaner.

D-1.7.1.3 Coat the passivated test panel with 25 to 37 m of nickel deposited from the same solution and using the same conditions as for the coated articles, to ensure that the test portion will be representative of the coated article.

D-1.7.1.4 Remove the edge of the electroplated test panel with a hand or power shear or by any other convenient method that permits ready separation of the test foil.

D-1.7.1.5 Separate the test foil from the test panel, wash it with water to remove any electrolyte and dry by dabbing with, for example, filter paper. Cut the foil into pieces 2 to 3 mm square with a scissors. Transfer the pieces to a 100 ml beaker, cover with water, and heat to boiling. Pour off the water, wash the pieces with methanol and allow them to dry in the atmosphere, on filter paper.

D-1.7.2 Test Portion and Standard Material

Depending on the expected sulphur content of the product, weigh, separately, to the nearest 0.000 1 g, the amount of the nickel test foil (D-1.7.1) and the

appropriate standard materials (see D-1.7.3) indicated below:

<i>Expected Sulphur Content</i> percent (m/m)	<i>Mass of Test Portion or Standard Material</i> g
From 0.005 up to and including 0.10	1.00 ± 0.02
Above 0.10 to 0.50	0.20 ± 0.02

D-1.7.3 Calibration

Select a minimum of two standards with sulphur contents near the upper and lower limits of the expected range for the test portion and also one near the mean. The mean standard may be prepared, if necessary, by taking equal amounts of each of the other two. Weigh out appropriate amounts of each standard and determine their sulphur contents using the same procedure as specified in D-1.7.4.

D-1.7.4 Determination

D-1.7.4.1 Add 1 g of the iron chips (D-1.4.2), 0.8 g of the iron powder (D-1.4.3), and 0.9 g of the tin (D-1.4.7) to the crucible (D-1.6). Add the test portion (D-1.7.2) and close the crucible with its lid.

D-1.7.4.2 Assemble the heating apparatus (see D-1.6). Switch on the induction furnace and allow it to attain its operating temperature. Pass the oxygen (D-1.4.8) through the apparatus at a rate of 1.0 to 1.5 l/min (see Note 1) and full the sulphur dioxide absorption vessel to a predetermined point with the hydrochloric acid (D-1.4.1) (see Note 2). Add 2 ml of the starch-iodide solution (D-1.4.6). Continuing the oxygen flow, add the appropriate potassium iodate solution (D-1.4.4) or (D-1.4.5) from the burette until a faint blue colour, to be taken as the end-point, is produced. Refill the burette.

NOTES

1 The oxygen flow rate may be adjusted to meet the requirements of individual operators or equipment; however, the flow rate has to be the same for the test samples and the standard samples.

2 Always fill the titration vessel to the same point.

D-1.7.4.3 After the furnace has been at operating temperature for at least 45 s, place the covered crucible containing the test portion and accelerators on the furnace pedestal, with the oxygen flow adjusted to 1.0 to 1.5 l/min, raise the crucible, close the furnace, and switch on the power. Heat the sample for 8 to 10 min, titrating continuously with the appropriate potassium iodate standard solution at such a rate to maintain the original intensity of the blue colour as constant as possible. The end-point is reached when this blue colour is stable for 1 min. Record the final burette reading and empty the titration vessel through the exhaust stopcock.

D-1.8 Blank Test

Carry out a blank test immediately after the determination, following the same procedure and using the same quantities of reagents but omitting the test portion. Use a pre-ignited crucible for this test.

D-1.9 Expression of Results

D-1.9.1 Sulphur Factor of Potassium Iodate Solution

The sulphur factor F , expressed as grams of sulphur (S) per millimetre of potassium iodate solution, is given by the equation:

$$F = \frac{m_1 \times a}{(V_1 - V_2)} \times 100$$

where

m_1 = mass, in grams, of the standard used in the calibration determination;

a = sulphur content, expressed as a percentage by mass, of the standard;

V_1 = volume, in millilitres, of the standard potassium iodate solution used in the calibration determination; and

V_2 = volume, in millilitres, of the standard potassium iodate solution used in the corresponding blank test.

D-1.9.2 Sulphur Content

The sulphur content expressed as a percentage by mass as sulphur (S), is given by the formula:

$$\frac{(V_2 - V_4) \times F}{m} \times 100$$

where

V_2 = volume, in millilitres, of the standard potassium iodate solution used in the determination;

V_4 = volume, in millilitres, of the standard potassium iodate solution used in the blank test;

F = mean sulphur factor (see D-1.9.1) for the standard used; and

m = mass, in grams, of the test portion.

D-2 DETERMINATION OF SULPHIDE FORMATION AND IODATE TITRIMETRY

D-2.1 Scope and Field of Application

This part of this annex specifies a titrimetric method for the determination of the sulphur content of electrodeposited nickel. It is applicable to products having sulphur contents, expressed as S, in the range 0.005 to 0.2 percent (m/m).

D-2.2 Principle

Conversion of sulphide sulphur to hydrogen sulphide by treatment with hydrochloric acid containing dissolved hexachloroplatinic acid, as an accelerator for dissolution. Reaction of hydrogen sulphide with ammoniacal zinc sulphate and titration of zinc sulphide formed with standard volumetric potassium iodate solution. Results are based on potassium iodate as the primary standard.

D-2.3 Reagents

During the analysis, use only reagents of recognized analytical grade and only distilled water or water of equivalent purity.

D-2.3.1 Ammoniacal Zinc Sulphate Solution

Dissolve 50 g of zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) in 250 ml of water, add 250 ml of ammonia solution, ($\rho = 0.9 \text{ g/ml}$) 0.90 g/ml and mix. Transfer the solution to a flask and allow to stand for approximately 24 h; filter it into a polyethylene bottle.

D-2.3.2 Hexachloroplatinic Acid, 10 g/l Solution

Dissolve 0.5 g of hexachloroplatinic acid ($\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$) in about 40 ml of water, add 5 ml of hydrochloric acid solution (D-1.4.1), dilute to 50 ml and mix.

D-2.3.3 Hydrochloric Acid — Hexachloroplatinic Acid Solution

Prepare 500 ml of a solution containing 1 volume of hydrochloric acid (D-1.4.1) and 1 volume of water. Add 2.5 ml of the hexachloroplatinic acid solution (D-2.3.2) and mix.

D-2.3.4 Standard Potassium Iodate Solution, 0.1 m.

Dry some crystals of potassium iodate (KIO_3) at 100°C for 1 h. Dissolve 3.570 g of the dried potassium iodate in about 200 ml of water, transfer to a 1 000 ml one-mark volumetric flask, dilute to the mark and mix.

D-2.3.4.1 Standard potassium iodate, standard solution (0.005 m).

Transfer 25 ml of the standard volumetric potassium iodate solution (D-2.3.4) to a 500 ml one-mark volumetric flask with a pipette, dilute to the mark and mix.

D-2.3.5 Starch-Iodide Solution

Add about 5 ml of water to 1 g of soluble starch with stirring until a paste is formed. Add the paste to 100 ml of boiling water and mix. Cool the solution, add 5 g of potassium iodide (KI) and stir until the potassium iodide is dissolved.

D-2.3.6 Dilute Hydrochloric Acid, (1:1) (v/v).

D-2.3.7 Nitrogen, supplied from cylinder, fitted with valves and pressure regulator.

D-2.4 Apparatus

D-2.4.1 Hydrogen Sulphide Evolution Apparatus (Fig. 1), comprising :

- Erlenmeyer flask, of capacity 250 ml;
- a wash bottle fitting with an exit tube, leading to
- a receiving flask.

The Erlenmeyer flask can be heated by an electric hot-plate.

D-2.4.2 Burette, of capacity 10 ml.

D-2.5 Procedure

D-2.5.1 Nickel Test Foil

Prepare test sample as specified in D-1.7.1.

D-2.5.2 Test Portion

Depending on the expected sulphur content of the product, weigh to the nearest 0.000 1 g, the amount of the nickel test foil (D-2.5.1) indicated below:

Expected Sulphur Content percent (m/m)	Mass of Sample g
0.005 to 0.07	1.00 ± 0.02
0.05 to 0.2	0.40 ± 0.02

D-2.5.3 Determination

D-2.5.3.1 Transfer the test portion (D-2.5.2) to the 250 ml evolution flask [D-2.4.1 (a)] and add 25 ml of water.

D-2.5.3.2 Add 20 ml of water and 3 ml of the ammoniacal zinc sulphate solution (D-2.3.1) to the receiving flask (D-2.4.1 c).

D-2.5.3.3 Adjust the hot-plate to maintain the temperature of the water in the evolution flask at 80°C .

D-2.5.3.4 Add 15 ml of the hydrochloric acid hexachloroplatinic acid solution (D-2.3.3) to the evolution flask. Quickly assemble the apparatus as shown in the figure and pass a very gentle stream of the nitrogen (D-2.3.7) through the apparatus.

NOTE — Flow of about 30 ml/min is satisfactory. If the sample dissolves rapidly, the flow should be decreased during the time that hydrogen is freely liberated.

D-2.5.3.5 Continue the heating and flow of nitrogen until the sample is completely dissolved, and for a further 5 min. Detach the gas delivery tube from the evolution head and remove the receiving flask with the delivery tube.

NOTE — The solution in the receiving flask will remain alkaline throughout the dissolution period if the hot-plate temperature and the nitrogen flow are properly adjusted.

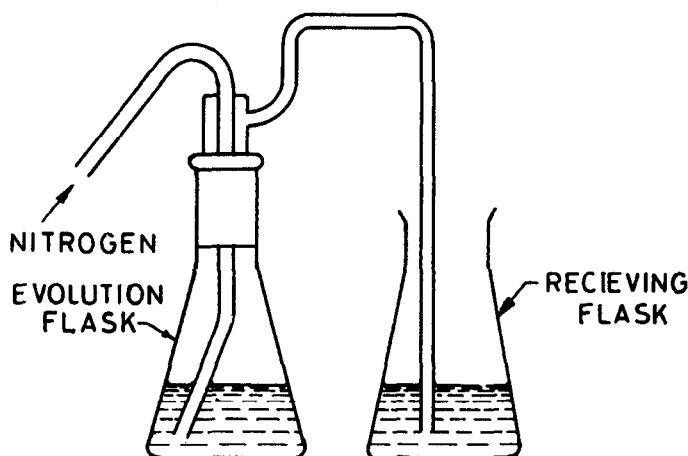


FIG. 1 APPARATUS FOR DETERMINATION OF SULPHUR CONTENT OF ELECTROPLATED NICKEL FOIL BY SULPHIDE FORMATION

Additional ammoniacal zinc sulphate solution (D-2.3.1) may be added, if necessary, but the test portion should be discarded if the receiving solution becomes acidic (less than pH 7 to test paper).

D-2.5.3.6 Add 1 ml of the starch-iodide solution (D-2.3.5), and 5 ml of the hydrochloric acid solution (D-2.3.6) to the receiving flask and mix. Titrate immediately with the standard potassium iodate solution (D-2.3.4.1) from the 10 ml burette (D-2.4.2), to the first blue colour. Draw some of the solution into the delivery tube with a rubber bulb and release along the neck of the flask to wash down any adhering zinc sulphate. Swirl the solution of the flask to wash the outside of the tube. Continue the titration to a permanent blue colour.

D-2.6 Blank Test

Carry out a blank test to the same starch — iodine colour on a mixture of 20 ml of water, 3 ml of the ammoniacal zinc sulphate (D-2.3.1), 1 ml of the starch — iodate solution (D-2.3.5) and 5 ml of the hydro-

chloric acid solution (D-2.3.6) in a 250 ml Erlenmeyer flask.

D-2.7 Expression of Results

The sulphur content, expressed as a percentage by mass as sulphur (S), is given by the formula:

$$\frac{(V_1 - V_2) \times 0.005 \times 0.016}{m} \times 100$$

$$= \frac{(V_1 - V_2) \times 0.008}{m}$$

where

V_1 = volume, in millilitres, of the standard volumetric potassium iodate solution (D-2.3.4.1) used for determination;

V_2 = volume, in millilitres, of the standard volumetric potassium iodate solution (D-2.3.4.1) used for the determination;

m = mass, in grams, of the test portion.

ANNEX E

(Clause 7.2.4.2)

DETERMINATION OF THE NUMBER OF DISCONTINUITIES IN CHROMIUM COATINGS

E-1 SCOPE AND FIELD OF APPLICATION

This annex specifies a method for determining the number of discontinuities in chromium coatings on production parts.

E-2 PRINCIPLE

Cathodic deposition of copper under defined conditions on a representative area of a production

part, whereby copper is deposited only on the underlying nickel that is exposed through discontinuities in the chromium. Assessment of the discontinuities in the terms of the number of copper nodules deposited with a given area or the number of cracks revealed in a given length.

E-3 APPARATUS

Ordinary laboratory apparatus and plating bath, by

means of which copper may be deposited cathodically on the test piece.

The bath solution contains 200 g/l of copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) and 20 g/l of sulphuric acid (H_2SO_4) and shall be maintained at a temperature of 18° to 24°C throughout the determination. The cathode current density used is 30A/m^2 .

E-4 PROCEDURE

E-4.1 Preparation of the Test Piece

Prepare the test piece as follows.

Mask all edges not covered by the chromium coating with a non-conductivity paint or pressure sensitive tape, including the wire used to make contact to the cathode bar of the plating bath. Clean by immersion in a hot alkaline cleaner at a temperature not exceeding 65°C until the surface is homogeneously wetted. A gentle scrubbing with a soft brush is helpful. Thoroughly rinse in cold running water, and then immerse for 5 to 10 s in approximately 5 percent (m/m) sulphuric acid solution. In cases where the test is applied several days after chromium deposition, immerse the test piece in a solution containing 10 to 20 g of nitric acid per litre for 4 min at approximately

65°C before the copper deposition stage, to help reveal the cracks or pores.

E-4.2 Determination

Connect the test piece and the anode to the current supply before immersion. Immerse both electrodes in the plating bath (E-3) and deposit copper cathodically on the prepared test piece with a cathode current density 30A/m^2 . Use an immersion time of approximately 1 to 5 min at a temperature of 18° to 24°C . The copper will deposit only on the underlying nickel that is exposed through discontinuities (pores and cracks) in the chromium.

Carefully remove the test piece, rinse in cold and then in hot water and air-dry (do not use compressed air). The test piece shall not be wiped where pores or cracks are to be counted.

Estimate the number of discontinuities in the chromium by counting the copper nodules deposited within a known area or the number of cracks in a known length of the test piece. These determinations may be carried out using either a metallurgical microscope fitted with a calibrated reticle in the eyepiece, or from microphotographs taken of a representative field of the test piece.

ANNEX F

(Clause 7.4)

MODIFIED FERROXYL TEST

F-1 GENERAL

This method reveals discontinuities such as pores, in electroplated nickel on iron or steel.

F-2 TEST SOLUTION

F-2.1 Solution A is prepared by dissolving 50 g of white gelatine and 50 g of sodium chloride in one litre of warm (45°C) distilled water.

F-2.2 Solution B is prepared by dissolving 50 g of sodium chloride and 1 g of non-ionic wetting agent in one litre of distilled water.

F-2.3 Solution C is prepared by dissolving 10 g of potassium ferricyanide in one litre of distilled water.

F-3 PROCEDURE

Filter paper strips are immersed in solution A, which is kept sufficiently warm to keep the gelatine dissolved, and then allowed to dry. Just before use, immerse the dry filter paper strips in solution B just long enough to thoroughly wet all of the filter paper. Firmly press the filter paper against the thoroughly cleaned and degreased electroplated nickel surface to be

tested. Allow 10 min contact time for the test period (see Note). If the filter paper should become dry during the test, moisten again with solution B. Remove the papers at the end of the contact period, and place at once into solution C. Sharply defined blue markings will appear on the papers indicating basis metal corrosion or porosity.

NOTE — This test is slightly corrosive to nickel particularly if the test period is extended appreciably (3 minutes or more) beyond the 10 minutes period. The test is very sensitive to the superficial pressure of iron that is, blue spots can occur on an electrodeposited nickel surface that has been in sufficient contact with a piece of iron to leave a trace of the irons on the nickel surface.

F-4 REPORT

The following information shall be included in the report.

The area of surface tested.

The total number and diameter of all spots on the filter paper used for surface area tested.

The highest number of spots visible within a square area as defined and specified by the purchaser.

ANNEX G
(Clause 9.1.1)

DETERMINATION OF CHROMIUM THICKNESS BY COULOMETRIC METHOD

G-1 PRINCIPLE

The method is based on the measurement of the quantity of electricity required to dissolve anodically an electrodeposited coating over a known area.

G-2 TEST SOLUTION

Dilute 62 ml of orthophosphoric acid (sp-gr 1.75) to 1 litre.

G-3 PROCEDURE

G-3.1 Clean the area to be tested with a cloth, wetted with an organic solvent for grease removal, if necessary.

G-3.2 Press an electrolytic cell, fitted with a flexible sealing ring incorporating an annular cathode on the coating so that a circle of known area is exposed to the test solution. Introduce the test solution into the cell; insert the stirrer if appropriate to the instrument used and the thickness of the deposit.

G-3.3 Make the electrical connections with the specimen being anodic. Continue electrolysis until dissolution of the chromium coating is complete, as indicated by sudden change in anode potential, and record the quantity of electricity consumed.

G-3.4 Examine the specimen and ensure that chromium removal is complete over the area of the cell.

G-4 CALCULATION

Calculate the thickness of the chromium coating from the following formula assuming 100 percent current efficiency:

$$\text{Thickness, } \mu\text{m} = \frac{Q}{A} \times 12.6$$

where

Q = quantity of electricity consumed (columbs),
and

A = area tested (mm^2).

ANNEX H
(Clause 9.2)

FILE TEST FOR ADHESION

H-1 The file test shall be carried out as follows:

H-1.1 Saw piece off a plated article, hold it in a vice and apply a coarse file to the outer edge in such a manner as to raise the deposit. File with direction

from the basis metal to the coating at an angle of approximately 45° to the coated surface.

H-1.2 There shall be no separation between the coating and the basis metal nor between the layers of a multiple coating.

ANNEX J
(Clause 9.2)

QUENCHING TEST FOR ADHESION

J-1 PROCEDURE

J-1.1 Heat a plated article for a sufficient time in an oven for it to reach the temperature shown in Table 8 with a tolerance of $+10^\circ\text{C}$. Then quench the part in water at room temperature. The appearance of blisters or peeling shall give evidence of inadequate adhesion.

Table 8 Recommended Quenching Test Temperature

(Clause J-1.1)

Substrate	Temperature, $^\circ\text{C}$
Steel	250
Zinc alloys	150
Copper and copper alloys	250
Aluminium and aluminium alloy	220

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